

New Evidence on the Performance of Customer Options Trades[☆]

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Abstract

Recent research claims that retail options traders experience losses on average. Notably, Bryzgalova, Pavlova and Sikorskaya (2023) (BPS) claim trades executed in single-leg improvement mechanisms (SLIMs), their proxy for retail trades, suffer losses. The BPS performance estimates are sensitive to their estimates of trade direction and use of quotes prior to expiration, rather than expiration values, to compute performance. Using expiration values and Cboe data that include trade directions, we find that Cboe customer SLIM trades are on average profitable. The similarity between trades on the Cboe and non-Cboe exchanges suggests that SLIM trades on non-Cboe exchanges also are profitable.

JEL Classification: G12, G13, G23, G24

Keywords: Retail options trading, options trading, price improvement auctions, single-leg improvement mechanisms, retail investment performance

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Abstract

Recent research claims that retail options traders experience losses on average. Notably, Bryzgalova, Pavlova and Sikorskaya (2023) (BPS) claim trades executed in single-leg improvement mechanisms (SLIMs), their proxy for retail trades, suffer losses. The BPS performance estimates are sensitive to their estimates of trade direction and use of quotes prior to expiration, rather than expiration values, to compute performance. Using expiration values and Cboe data that include trade directions, we find that Cboe customer SLIM trades are on average profitable. The similarity between trades on the Cboe and non-Cboe exchanges suggests that SLIM trades on non-Cboe exchanges also are profitable.

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1. Introduction

Several recent papers use proxies for retail options trading to study its profitability. Based on these proxies, they conclude that retail investors generally lose money trading options. Bryzgalova, Pavlova, and Sikorskaya (2023) (BPS) use trading in single-leg price improvement auctions as a proxy for retail trading and conclude that, on average, retail options traders experience losses at every trade horizon they consider. Silva, Smith, and So (2022) equate the customer classification in the NOTO and PHOTO data on signed options volume with retail trading and conclude that retail traders suffer losses on their trading around earnings announcement dates. Naranjo, Nimalendran, and Wu (2024) study data on complex options trades from a single unidentified options exchange. Using the customer trading capacity as a proxy for retail trading, they conclude that retail traders generally suffer losses on their complex trades. Beckmeyer, Branger, and Gayda (2023) present evidence that retail traders lose money trading options on the S&P 500 index, using trading in the single-leg and complex price improvement auctions as a proxy for retail trading. Bogousslavsky and Muravyev (2025) use data from a social investing platform and find that the approximately 3,000 traders who shared their trades via the platform on average experience small losses on their single-leg options trades.

Some of these studies suffer from obvious limitations. For example, the customer classification includes all trades by public customers, including trades by hedge funds, mutual funds, and other institutional investors. The decision by Silva, Smith, and So (2022) to treat all customer trades as retail trades implicitly assumes that non-retail customers account for only a small fraction of customer trades. The work of Naranjo, Nimalendran, and Wu (2024) suffers from the same limitation. In addition, Naranjo, Nimalendran, and Wu (2024) use data from only a single options exchange, which may not be representative of trading on all exchanges, study only the trades executed using the complex trading protocols, and do not take account of closing trades. Trading in the single-leg and complex auctions that Beckmeyer, Gayda, and Granger (2023) use as a proxy for retail trading accounts for only between 4% and 6% of trading in S&P 500 index options. This is an implausible low estimate of retail trading in S&P 500 options, indicating that the proxy used by Beckmeyer, Gayda, and Granger (2023) captures only a small fraction of retail trading in the S&P 500 options.¹ Finally, it is difficult to assess whether the sample of

¹ Fu, Li, Musto, and Pearson (2024) find that a large fraction of S&P 500 single-leg limit order book (LOB) options trades are for only one contract, suggesting that many retail trades are executed in the single-leg LOB.

approximately 3,000 active retail investors who shared their trades through a social investing platform used by Bogousslavsky and Muravyev (2025) is representative of the universe of retail investors.

Of these papers, the one by BPS has received the most attention.² BPS use Options Price Reporting Authority (OPRA) data on trades in single-leg price improvement auctions, which they refer to as single-leg improvement mechanisms (SLIMs), as a proxy for retail options trading. Because their OPRA trade data capture options trades on all exchanges, their analysis is not subject to the criticism that it is limited to one exchange or a self-selected group of investors. BPS find that, on average, retail options traders experience losses at every trade horizon they consider. Assuming all trades open new positions and a trading horizon of 10 days, they estimate that the aggregate portfolio of retail trades executed during their sample period running from November 2019 through June 2021 lost an average of $-\$5.03$ million per day, or a total of $\$2.1$ billion. Assuming that the options are held to expiration, BPS estimate that the aggregate portfolio of retail trades lost $-\$1.63$ million per day. And while the BPS SLIM proxy does not capture all retail trading, they present evidence that trading in SLIMs captures a meaningful fraction of retail options trading. Thus, the BPS sample is plausibly the one that is most representative of retail options trading. For these reasons, we focus on their paper.

In contrast to BPS, we find that customer SLIM trades executed on the two Cboe exchanges that offer SLIMs, CBOE and EDGX, were profitable during the period covered by our data. We obtain this result by exploiting data on trades executed on the Cboe exchanges covering the period running from January 2020 through June 2023 that we obtained from Cboe Global Markets. These data include the trading capacities (for example, customer or market maker) of the trade counterparties, the channel on which the trade was executed (for example, SLIM or the electronic LOB), which party bought and which sold, and, for the non-market maker capacities, whether the trade was an opening or a closing trade. A large fraction of the trades, slightly more than 42%,

² For example, this paper is published in the *Journal of Finance*, appeared on the programs of the Annual Meeting for the American Finance Association and the summer meeting of the National Bureau of Economic Research, and already has 110 citations, despite being published only in early 2023. This paper's findings that retail option traders lose money are cited in the *Economist* (<https://www.economist.com/graphic-detail/2023/03/07/retail-investors-are-losing-billions-buying-stock-options>), the *Wall Street Journal* (<https://www.wsj.com/finance/stocks/options-individual-investors-risk-gambling-a97bee1a>), *Trader's Magazine* (<https://www.tradersmagazine.com/am/research-finds-retail-options-traders-bet-big-bet-often/>), a Bloomberg podcast (<https://www.bloomberg.com/news/audio/2022-07-07/how-amateurs-lost-billions-on-options-podcast>), and Risk.net (<https://www.risk.net/investing/7954462/its-amateur-hour-how-retail-traders-upended-options-market>).

close previously opened positions. BPS claim that retail investors fall into two groups: those who buy short-term options and incur losses, and those who sell these options and earn substantial profits, even after transaction costs. We show that, in practice, most investors are opening buy positions in call options, and the observed "sellers" are predominantly closing out these earlier purchases—not opening new short positions.

We focus on the net performance of trades over their life cycles, that is, from when they are opened to when they are closed, either by a closing trade or by option expiration.³ We focus on profits over the entire life cycle because this is the only horizon over which we can take account of the impact of closing trades. While the data do not match the closing trades to their corresponding opening trades, the identification of closing trades allows us to determine the impact of all closing trades on the aggregate lifecycle profitability of all trades in an options series, as we explain in Section 3.2. We estimate the average net profitability of Cboe customer SLIM trades to be \$0.34 million per day (t -statistic 0.29) during our sample period of January 2020 through June 2023. We also consider a sample period of January 2020 through June 2021, which matches the BPS November 2019-June 2021 sample period except that it does not include the first two months of the BPS sample period. We estimate the average net profitability of Cboe customer SLIM trades to be \$2.07 million per day (t -statistic 1.19) during this January 2020-June 2021 sample period.

The t -statistics indicate that our performance estimates are not statistically significant at conventional significance levels. This should not be surprising, as the exercise of estimating average profitability is very similar to the exercise of estimating expected returns. It is well understood that expected returns cannot be estimated with precision using samples of only a few years, because the variability in returns is typically large relative to the expected return (see, for example, Merton (1980)). Due to the return variability, estimates of average performance based on a sample of only a few years are inherently imprecise. However, we can state that our results provide no evidence that Cboe customer SLIM trades are unprofitable.

Purchases of calls and sales of puts display positive performance during both sample periods, while purchases of puts and sales of calls are not. This pattern is to be expected: stock prices, as measured by the S&P 500 index, increased by 33% and 38% over the January 2020-June

³ BPS present results for both gross and net performance of the trades, where the net performance is computed using the actual trade price and the gross performance is computed based on the counterfactual assumption that the trade price equals to midpoint of the NBBO quotes attached to the OPRA trade record. We focus on the net performance, because that corresponds more closely to the performance experienced by the investors.

2021 and January 2020-June 2023 sample periods, respectively.⁴ Purchased calls and written puts provide positive exposure to stock price movements, and thus should be expected to profit when stock prices rise, while purchased puts and written calls provide negative exposure to stock price movements, and thus should be expected to experience losses when stock prices increase. Although their results for the overall performance of retails trades differ from ours, BPS find similar patterns in the performance of purchased and written calls and puts. Overall, call trades experienced gains and put trades experienced losses, because majorities of both call and put opening trades are purchases. Given the frequency of different kinds of trades, e.g. the most common opening trade is a purchase of a call, and the fact that the S&P 500 index increased, our finding of positive overall performance should not be surprising.

We identify two reasons that explain why we find overall positive net performance while BPS find overall negative net performance. First, BPS handle expiring options in a surprising way. Rather than compute the profit or loss of an expiring option as the difference between the expiration value and the purchase price, they compute it as the difference between the NBBO midpoint at the time of the last trade prior to expiration and the purchase price. In other words, they estimate the expiration value using the NBBO midpoint at the time of the last trade prior to expiration. This affects estimates of profitability, because the NBBO midpoint is often a biased estimate of the expiration value. Specifically, the NBBO midpoints of soon-to-expire well out-of-the-money (OTM) options tend to be greater than expected expiration values, because options offer prices are always at least one tick and often greater than one tick, while NBBO midpoints of soon-to-expire well in-the-money (ITM) options tend to be less than the options' expiration values (Battalio, Figlewski, and Neal, 2020). The net effect of using the expiration values in place of the NBBO midpoints is that the estimate of the profitability of options held to expiration changes from negative to positive, using the same OPRA trade data that BPS use.

Second, BPS do not know the trade directions (buy/sell) of the trades in their sample, but estimate trade direction using a version of the quote rule. In addition to the OPRA trade data BPS use, we have more detailed data on trades executed on the Cboe exchanges, for a sample period that includes all but the first two months of the BPS sample period. These more detailed Cboe data include the trade directions. Using these data and estimating the trade direction as BPS do, we find

⁴ The S&P 500 index closed at 3,230.78 on December 31, 2019, 4,297.50 on June 30, 2021, and 4,450.38 on June 30, 2023.

that the average performance of Cboe customer SLIM trades that are held to expiration is negative during this period. However, when we use the correct trade direction, our estimate of the average performance of customer SLIM trades that are held to expiration is positive.

We begin our analyses with an initial step in which we show that many characteristics of Cboe SLIM trades resemble those of non-Cboe SLIM trades. This suggests that the results we obtain and conclusions we reach using the Cboe data are also relevant for SLIM trades executed on the non-Cboe exchanges. We also find that more than 98% of Cboe SLIM trades are between a customer and either a market maker, firm proprietary trader, or broker-dealer.

We then present our main results on the performance of Cboe customer SLIM trades. As indicated above, we focus on the net performance of the trades over their entire life cycles, that is, from when they are opened to when they are closed, taking account of closing trades as explained in Section 3.1. We compute the performance of an option held to expiration using its expiration value rather than the NBBO midpoint at the time of the last trade. As indicated above, we find that Cboe customer SLIM trades executed during both the January 2020-June 2021 and January 2020-June 2023 sample periods are on average profitable, although the average profits are not statistically significant. Our results for the January 2020-June 2021 sample contrast with the findings reported by BPS for options held to expiration.

We then turn to exploring possible reasons why our results for the overall performance of options trades over their life cycles differ from those of BPS for options held to expiration. BPS use OPRA trade data over the period running from November 4, 2019 through June 2021. We use our OPRA trade data over the same period to replicate the BPS analysis of performance, and obtain results similar to theirs.

In computing profits, BPS “use the last available [midpoint] price when the data for a certain horizon are not available” (BPS fn. 35). This choice has two implications. First, although BPS fn. 35 does not make this entirely clear, examination of the BPS replication package reveals that when options are held to expiration they compute profits using these midpoints rather than the options’ expiration values. For example, consider an option that expires out-of-the money (OTM), for which the last reported quotes are a bid of zero and an offer of \$0.20. In this case BPS compute the profit of holding the option to expiration using the bid-ask midpoint of \$0.10 ($= (\$0.00 + \$0.20)/2$) rather than the exercise value of zero. This approach overstates the profits (losses) of purchased (written) options that expire OTM, because the offer price, and thus the bid-ask

midpoint, of an option that expires OTM is always strictly positive. On the other hand, the midpoint of the last quotes of an option that expires in-the-money (ITM) is typically below the exercise value (Battalio, Figlewski, and Neal, 2020). In this case, the BPS approach overstates the losses (profits) of purchased (written) options that are well ITM when they expire. The net effect of these two biases depends on the mix of purchased and written positions, and the fractions of the purchased and written options that expire OTM and ITM.

The choice to “use the last available [midpoint] price when the data for a certain horizon are not available” has a second implication. BPS compute profits for several horizons, these being intraday, one, two, five, and ten days, and through to expiration. On the last day of the one, two, five, and ten-day horizons, the price data for options that expired on earlier days are not available. For example, at the ten-day horizon, options that expired on days zero through nine do not have price data on day ten; rather, the “the last available [midpoint] price” is from the expiration date of the option. In computing the profits or losses for a given horizon, BPS do not exclude the options that expire before the end of the horizon, but instead use “the last available price,” even when this is the price of an option that expired before the end of the horizon. As a result, the profits for each horizon less than ten days are included in the profits/losses for each longer horizon up to ten days. For example, the large intraday losses BPS compute are included in the one, two, five, and ten days horizons.

BPS find negative net performance at all horizons they consider. In their sample, when we use the expiration values to compute performance, and do not include the profits of earlier-expiring options in the losses for longer horizons, net performance improves at all horizons. Average losses at the five-day and ten-day horizons are reduced by more than half, and become statistically insignificant. The average performance of options held to expiration improves from $-\$1.75$ million per day to $\$0.36$ million per day, an increase of $\$2.11$ million per day. We also find that average net performance of options held to expiration is positive using a sample of trades executed between January 2020 and June 2023.

We next turn to the impact of using estimates of trade direction (buy/sell) in place of the correct trade directions. BPS do not know the direction of their trades, but rather follow Muravyev (2016) and estimate trade direction using a version of the quote rule.⁵ We have the correct trade

⁵ Specifically, SLIM trades with prices greater (less) than the midpoint of the NBBO quotes attached to the trade record are signed as buys (sells). If the trade price equals the NBBO midpoint, BPS next compare the trade price to

directions for the trades executed on the Cboe exchanges, but not those executed on non-Cboe exchanges, so we can only study the impact of trade direction for the Cboe trades. For Cboe SLIM trades, the version of the quote rule used by BPS misclassifies 42.4% of trades and 42.6% of trading volume.

Before we examine the impact of using the correct trade direction, we first show that the patterns in the trade performance on the Cboe exchanges resemble the patterns in the performance of non-Cboe trades. We find that the average performance of SLIM trades executed on the Cboe exchanges and assumed held for various horizons are consistent with the profits of SLIM trades on all exchanges and the Cboe exchanges' share of SLIM trading volume. This suggests that our results based on Cboe SLIM trades are likely relevant for SLIM trades on all exchanges. We also find that the daily average performance of Cboe customer SLIM trades resembles the daily average performance of all Cboe SLIM trades; this is because more than 98% of Cboe SLIM trading is due to customers.

To study the impact of trade direction, we compute estimates of customer performance in two different ways: (a) applying the quote rule used by BPS, and (b) using the correct trade direction. Using the quote rule, the results show customer losses at all horizons except for ten days. The losses at the intraday horizon are large (\$1 million per day), and highly statistically significant, and the losses at the one-day horizon are significant at the 10% level. Using the correct trade direction, the results show losses at only two horizons, intraday and two days, with only the loss at the intraday horizon being statistically significant. The gains assuming options are held to expiration are large, \$2.07 million per day, though not statistically significant (t -statistic = 1.19). These results show that the combination of changes to the BPS approach eliminate most of the evidence of losses. In BPS, the losses are large at all horizons, and statistically significant except when it is assumed that options are held to expiration. Once we make the changes, there are losses at only two horizons, and statistically significant losses at only the intraday horizon.

The next section of the paper discusses the OPRA and Cboe trade data we use. In Section 3 we explain how the trade directions in the Cboe data allow us to take account of closing trades, and then present our main estimates of the net performance of customer SLIM trades. In Section

the midpoint of the BBO quotes of the exchange on which the trade occurred, and sign the trade as a buy (sell) if the trade price is greater (less) than the BBO midpoint. If the trade price, NBBO midpoint, and BBO midpoint are equal, the trade direction is not estimated, and the trade is classified as a "midpoint" traded.

4 we explore how BPS' choice to compute the performance of trades held to expiration using the midpoint of the NBBO quotes attached to the last trade prior to expiration rather than the expiration values affects their estimates of net performance. Section 5 shows how using the correct trade directions instead of trade directions estimated using a version of the quote rule impacts the net performance of SLIM trades executed on the Cboe exchanges. Section 6 briefly concludes.

2. Data

Our main dataset consists of records of all single-name and ETF options trades executed on one of the four Cboe exchanges during the period running from January 2020 through June 2023. These four Cboe exchanges are CBOE, EDGX, C2, and BATS. During our sample period, these four exchanges accounted for more than 30% of the total volume in single-name options across all US options exchanges. Our analysis focuses on trades executed in single-leg price improvement auctions, which BPS refer to as single-leg improvement mechanism (SLIM) trades. Two of the Cboe exchanges, CBOE and EDGX, offer this trade protocol. SLIM trades executed on one of these two exchanges account for 28% of the total volume of SLIM trades across all exchanges that offer SLIMs.

We also use records of trades on all options exchanges to replicate some of the analyses in Bryzgalova, Pavlova, and Sikorskaya (2023). These trade records originally come from OPRA; we obtain them from Algoseek LLC. Following BPS, we remove canceled trades, trades with nonpositive size or price, and trades with a negative spread (difference between best ask and best bid), and we keep only those trades for which trade price is above the best bid minus spread and below the best ask plus spread. We aggregate trades of the same contract with the same quote time, exchange ID, trade price, and trade condition ID into one line. Similar to BPS, we also winsorize trade prices, sizes and spreads at the 99.5th percentile daily. We use end-of-day data option prices from OptionMetrics and stock prices from CRSP to compute the performance of trades over different trade horizons and to compute the option exercise values.

2.1 Cboe options trade data

We obtained from Cboe Global Markets the records of trades in single-name and ETF options that are executed on one of the four Cboe exchanges. Each single-leg trade, and each trade leg of each complex trade, appears as at least two trade records, one for the buyer and one for the seller. A trade appears as more than two trade records when the passive side of the trade is shared among multiple traders. Each trade record includes the option series traded, the trade date and

time, trade price, number of contracts, trading capacity of the trader, whether the option is purchased or sold, and the channel on which the trade occurred. For the non-market maker capacities, each trade record also indicates whether the trade opened a new options position or closed an existing position. We group the trading capacities provided in the Cboe data into the broader categories of customer, market maker, professional customer, firm, and broker-dealer.

BPS assume that SLIM trades are retail, and focus on them. Of the four Cboe exchanges, CBOE and EDGX offer SLIMs. We focus on the customer SLIM trades executed on these two exchanges.

BPS use a different dataset consisting of records of trades on all exchanges reported by OPRA that they obtained from Cboe Livevol. We also use OPRA records of trades on all options exchanges to replicate some of the BPS analyses. While we obtain the OPRA trade records from a different data vendor, Algoseek LLC, we have no reason to think that our OPRA trade records differ in any material way from the similar data used by BPS.

2.2 Cboe and non-Cboe trade characteristics

We begin by reporting summary statistics describing characteristics of the SLIM trades executed on the Cboe and non-Cboe exchanges. We examine the characteristics for both the Cboe and non-Cboe trades to determine whether there are any significant differences in the characteristics of the trades executed on the two groups of exchanges. We consider the same characteristics BPS report in their Table I, which allows the characteristics of the Cboe trades also to be compared to the characteristics of the SLIM trades reported in BPS Table I. Because we consider non-Cboe trades, and market conditions at the time of execution (e.g., quoted spreads) that are not available in the Cboe data, this analysis uses the OPRA trade records.

We report the results in Table 1. The different rows categorize trades by different characteristics, for example whether the trade involves a call or a put, the estimated trade direction (buy/sell), the trade sizes in both contracts and premium, the times to expiration, and various moneyness buckets. For each category, the first two columns show the percentages of the number of trades and trading volume in that category. The next two columns show the quoted and effective spreads at the time of the trades. The quoted spread is the difference between the NBBO prices attached to the trade record, divided by the midpoint. The effective spread is the absolute percentage deviation of the trade price from the NBBO midpoint price computed from the quotes attached to the trade records, multiplied by two

We estimate the trade direction using the same approach as BPS, who in turn follow Muravyev (2016).⁶ They first compare the trade price to the midpoint of the NBBO quotes attached to the trade record, and sign a trade as a buy (sell) if the trade price is above (below) the NBBO midpoint. If the trade price is equal to the NBBO midpoint, they look to the BBO midpoint on the exchange on which the trade was executed, and sign the trade as a buy (sell) if the trade price is above (below) the BBO midpoint. If the trade price, NBBO midpoint, and BBO midpoint on the exchange on which the trade occurred are equal, then the trade cannot be signed and is referred to as a midpoint trade.

Overall, the results show that the characteristics of Cboe SLIM trades resemble the corresponding characteristics of non-Cboe SLIM trades. For example, the results in the first row of the table shows that call trades account for 70.69% (69.94%) and 68.40% (68.44%) of the trades and trade volumes on the Cboe (non-Cboe) exchanges, and put trades account for 29.31% (31.60%) and 30.06% (31.56%) of the trades and trade volumes. They also show that the average quoted and effective spreads of call and put trades are similar on the Cboe and non-Cboe exchanges. The results for the Cboe and non-Cboe exchanges are similar for almost all of the other categories of trades for which results are displayed in the table. These results are also similar to the corresponding results in BPS Table I. This is to be expected, because the sample used for this table is almost the same as the sample used in BPS Table I (November 4, 2019 through June 2021).

There are only two exceptions to this general pattern in the characteristics of the Cboe and non-Cboe SLIM trade. First, when we categorize trades by trade direction, the results shows that somewhat fewer midpoint trades occur on the non-Cboe exchanges, and the quoted spreads at the times of these trades tend to be much wider on the non-Cboe exchanges. For call (put) trades, the quoted spreads on the Cboe and non-Cboe exchanges at the times of midpoint trades are 16.10% (14.38%) and 22.94% (19.35%), respectively. A second difference is that when we categorize trades by size, the Cboe trades of greater than 100 contracts have slightly larger quoted and effective spreads as compared to the non-Cboe trades in the same size category.

⁶ While the Cboe data contain the trade direction of each Cboe trade, the OPRA data do not include the trade direction. Thus, we do not know the correct trade direction for the non-Cboe trades. We estimate the trade direction of each trade using the version of the quote rule used by BPS, so that the trade directions of the Cboe and non-Cboe trades are estimated using the same approach.

These differences in the characteristics of trades on the Cboe and non-Cboe exchanges apply to relatively few trades, as there are few midpoint trades or trades of more than 100 contracts. Thus, the characteristics of Cboe and non-Cboe trades are similar for the categories that include almost all trades. Many of the results discussed in the remainder of the paper are obtained using the Cboe trade data. The similarity of the characteristics of trades executed on the Cboe and non-Cboe exchanges suggests that the conclusions we draw from them likely also apply to trades executed on all SLIM exchanges.

2.3 Who trades in the SLIMs?

We next use the Cboe data to explore who trades with whom in the CBOE and EDGX SLIMs. In Table 2 we report the percentages of SLIM trading volume on CBOE and EDGX due to the buys and sells of each trading capacity. Each entry displays the percentage of total volume due to buys by the trading capacity indicated in the row label and sells by the capacity indicated in the column heading. The sample period is January 2020 through June 2023. The percentages do not sum to 100% because there are a few trades executed by traders with capacities not included in the table.

The results show that SLIM trading consists predominantly of trades between customers and market makers. On CBOE (EDGX), 46.97% (46.67%) of trading volume is due to market maker buys and customer sells, and 46.73% (46.43%) is due to customer buys and market maker sells. Trades between customers and firms account for 4.88% ($= 2.65\% + 2.23\%$) of CBOE volume and 3.02% ($= 1.68\% + 1.34\%$) of EDGX volume. Customer trades with other customers on CBOE (EDGX) account for only 0.57% (0.60%) of volume. Such trades can occur when orders submitted to the SLIM interact with customer orders on the electronic limit order book (LOB). Trades involving professional customers and broker-dealers account for very small percentages of volume. There are no market maker to market maker trades, because market makers are not allowed to initiate SLIM trades with proprietary orders.

For completeness, in Table 3 we report the results of a similar analysis of who trades with whom in the Cboe exchanges' electronic LOBs. The results show that trades between customers and market makers account for smaller percentages of LOB trading. For example, 39.81% (34.92%) of trading volume on the CBOE LOB is due to market maker buys and customer sells (customer buys and market maker sells). Slightly over 9% of volume is due to trades between market makers, and 5% is due to trades between customers. On EDGX, trades between customers

and market makers account for larger fractions of trading volumes, while customer-to-customer and market maker to-market maker trades account for smaller fractions of trading volume. C2 and BATS stand out due to the high and low percentages of market maker to market maker trades. On C2, 20.43% of volume is due to such trades, while BATS does not have any market maker to market maker trades.

3. Performance of customer SLIM trades

We use the Cboe trade data to estimate the performance of customer SLIM trades. One issue is what to do about closing trades. BPS assume that all trades are opening trades that are held to expiration. While this is obviously not the case, it might be a reasonable assumption if SLIM trades are predominantly opening trades. In this section we first explore the prevalence of closing trades, and how it varies with time to expiration. We then explain how the Cboe data allow us to account for closing trades, and finally turn to the performance estimates that take account of closing trades.

3.1 Prevalence of closing trades

During the January 2020-June 2023 sample period, 42.4% (57.6%) of Cboe SLIM trades are closing (opening) trades, and these trades account for 42.6% (57.4%) of Cboe SLIM volume. During the January 2020-June 2021 sample period that includes all but the first two months of the BPS sample period, closing (opening) trades account for 42.9% (57.1%) and 42.7% (57.3%) of Cboe SLIM trades and volume, respectively. These results imply that most options positions are not held to expiration. For example, if opening and closing trades are 57.3% and 42.7% of volume, then only $14.6\% = 57.3\% - 42.7\%$ of volume is due to opening trades that are held to expiration, and only $14.6\%/57.3\% = 25.5\%$ of opening trades are held to expiration.

The results displayed in Figure 1 Panel A use the January 2020-June 2023 sample to explore how the prevalence of SLIM opening and closing trades varies with time to expiration. To construct this figure, we first sort SLIM trades into buckets defined by the options' time to expiration. The buckets are 0, 1, 2, 3-5, 6-10, 11-21, 22-63, and greater than 63 days to expiration. Then for each bucket, we compute the ratio of the number SLIM trades in that bucket to the total number of SLIM trades during the sample period, so that the ratios sum to 100%. Figure 1 Panel A displays the results in the form of a stacked bar chart. The solid (striped) blue bars show the

results for opening (closing) buys, and the solid (striped) red bars show the results for opening (closing) sells.

Across all expirations, the largest bars are solid blue, indicating opening buys, and striped red, indicating closing sells. For example, the rightmost part of the figure shows that trades in options with more than 63 days to expiration account for 9.2% of all SLIM trades. Opening buys and closing sells in such options account for 3.8% and 2.5% of all SLIM trades; thus, even for such long-term options, the frequency of closing sells is more than two-thirds (2.5%/3.8%) the frequency of opening buys. Closing sells are also a significant fraction of opening buys for all other buckets. They are more common than closing buys for options with zero days to expiration, which is unsurprising.

Panels B and C display the results for call and put trades, respectively. Across all buckets, call (put) trades account for 65.1% (39.9%) of trades. The patterns in these panels are similar to those in Panel A.

3.2 Taking account of closing trades

While the Cboe trade records indicate whether each non-market maker trade was an opening or a closing trade, the data do not allow the closing trades to be matched to the trades that opened the positions. This complicates the computation of performance of trades in a specific direction (e.g., performance of buys), and makes it impossible to compute performance over any horizon other than over the trades' entire life cycles. For example, we cannot compute profits through five days, because the inability to match closing trades to their corresponding opening trades means that we do not know which of the opening trades are closed within five days. But it is possible to take account of closing trades when computing the aggregate profitability of trades over their life cycles, as we explain next.

Consider an option series, and suppose a researcher knows the opening buys and closing sells in that series executed by traders of a given capacity. The opening buys are indexed by $o \in O$, and executed at times t_o , and the closing sells are indexed by $c \in C$, and executed at times t_c . The number of closing trades must be less than or equal to the number of opening trades, that is the set C is smaller than the set O . We want to estimate the profit of the opening buys, taking account of the fact that some positions are closed before expiration. This is the sum of the profit of the opening buys, assuming the positions are held to expiration, adjusted by the profit of the

closing sells, computed by treating them as if they are opening sells that are held to expiration. Specifically, the profit is

$$\underbrace{\sum_{o \in O} (P_T - P_{t_o})}_{\text{profit from buy and hold to expiration}} + \underbrace{\sum_{c \in C} (P_{t_c} - P_T)}_{\text{profit from sell and hold to expiration}}, \quad (1)$$

where $P_T - P_{t_o}$ is the profit from buying at P_{t_o} and receiving P_T at expiry and $P_{t_c} - P_T$ is the profit from selling at P_{t_c} and delivering the value P_T at expiry.

To see that equation (1) gives the correct profit, note that each trade in C corresponds to a trade in O , because each position must be opened before it is closed. Even though we do not know which trades are closed, that is, we do not know the correspondence between the closing trades in C and the opening trades in O , we can divide the opening trades in O into a subset A consisting of trades that are held to expiration, and a complementary subset B that are closed prior to expiration. Doing this, we can rewrite (1) as

$$\sum_{o \in A} (P_T - P_{t_o}) + \sum_{o \in B} (P_T - P_{t_o}) + \sum_{c \in C} (P_{t_c} - P_T). \quad (2)$$

The first term in equation (2) is the profit of the opening trades $o \in A$ that are not closed.

For the opening trades, $o \in B$, that are closed, each opening trade has a corresponding closing trade, $c \in C$. That is, for each term $P_T - P_{t_o}$ there is a corresponding term $P_{t_c} - P_T$, and the sum

$$\underbrace{P_T - P_{t_o}}_{\text{profit of buy and hold to expiration}} + \underbrace{P_{t_c} - P_T}_{\text{profit of sell and hold to expiration}} = \underbrace{P_{t_c} - P_{t_o}}_{\text{profit of buy and later sell}} \quad (3)$$

is the correct profit of the round-trip trade. Thus, even though we cannot match the opening trades to their corresponding closing trades, the sum

$$\sum_{o \in B} (P_T - P_{t_o}) + \sum_{c \in C} (P_{t_c} - P_T)$$

is the profit of the set of opening trades that were closed prior to expiration. Thus, equation (2), and therefore also equation (1), correctly calculate the profits of the trades in an option series, taking account of the fact that some are later closed and some are held to expiration. The profit across all options series is just the sum across series of the profits for each of the series.

The above analysis is for opening buys, but a similar analysis applies to opening sells.

To apply this analysis to trades in a particular channel, it must be that all positions that are opened using trades executed on that channel are closed using trades executed on the same channel. For example, it must be that all trades that are opened using SLIMs are also closed using SLIMs. The results below are based on this assumption.⁷

3.3 Profitability estimates

We report estimates of customer performance that take account of closing trades in Table 4. The sample consists of all customer SLIM trades of stock and ETF options that expire on or before August 31, 2023 executed on CBOE or EDGX during the sample period running from January 2020 through June 2023.⁸ The trade directions (buy or sell) are included in the Cboe data. The expiration value P_T that appears in equations (1)-(3) is computed using the expiration date closing price of the underlying stock or ETF, that is, $P_T = 100 \times \max(S_T - K, 0)$ for a call and $P_T = 100 \times \max(K - S_T, 0)$ for a put. The table includes results for the average daily gross performance of all trades, open buys, open sells, and open buys and open sells of calls and puts. In each row, the performance of the opening trades is adjusted for the closing trades, as described in Section 3.2. For each trade, gross performance is computed using the prevailing NBBO midpoint at the time of the trade, where the NBBO bid and offer prices that are attached to the trade records are treated as the prevailing NBBO bid and offer. The calculation of gross performance using the midpoint follows BPS. Net performance is computed using the actual trade price, also following BPS. Because they are computed from the NBBO midpoints, the estimates of gross performance do not reflect any bid-ask spread costs of executing the trades. Neither the gross nor net performance reflect any commissions paid. t -statistics are in parentheses below the estimates of average daily performance.⁹

Customers sometimes trade with other customers, so that one is buying and the other is selling (Table 2). In these cases, we include both the buy and the sell as separate trades. Because the net of a buy and a sell is no trade, this does not impact the profits of all trades shown in the

⁷ We plan to incorporate trades executed on all channels in future work.

⁸ We require that the options expire on or before August 31, 2023 because we use the OptionMetrics data to determine the expiration values, and at the time we carried out the analysis the OptionMetrics data were available only through August 31, 2023.

⁹ The t -statistics are computed by first computing the profits of the trades executed in each day, resulting in a time series of daily profits. We then compute Newey-West t -statistics with the optimal lag length, in this case seven days, from the time series of daily profits.

first row of the table. This treatment of customer-to-customer trades impacts the results when we categorize trades according to whether they are buys or sells.

The results show that customer SLIM trades on the Cboe exchanges have positive performance during the January 2020-June 2023 sample period, with average daily gross and net performance of \$1.57 million per day (t -statistic 1.32) and \$0.34 million per day (t -statistic 0.29), respectively. The overall performance is driven primarily by call trades, and specifically by call buys, and secondarily by put sells. The average gross and net performance of call buys are \$2.80 million per day (t -statistic 2.04) and \$2.14 million per day (t -statistic 1.57), respectively. The same averages for sales of puts are \$0.49 million per day (t -statistic 0.89) and \$0.35 million per day (t -statistic 0.63). Call sells and put buys have negative performance on average, even on a gross basis.

Stock prices, as measured by the S&P 500 index, increased by 38% over the sample period, from 3,230.78 on December 31, 2019 to 4,450.38 on June 30, 2023. Given this, the results that call buys and put sells are profitable, while call sells and put buys are not, is to be expected. These results are also consistent with what asset pricing theory says about the unconditional expectations of options returns. Bought calls and written puts should have expected returns that exceed the risk-free rate, while sold calls and purchased puts should have expected returns lower than the risk-free rate. The fact that the overall performance is driven by call buys is also unsurprising, as call buys are far more frequent than call sells and put buys and sells.

In Table 5 we report results for a second sample period that overlaps, to the extent possible, the BPS sample period. This sample consists of all Cboe customer SLIM trades of stock and ETF options that expire on or before December 31, 2021 executed on one of the Cboe exchanges during the sample period running from January 2020 through June 2021. The ending date of June 2021 matches the ending date of the BPS sample. The beginning of the sample period differs by almost two months from the start of the BPS sample period, which begins on November 4, 2019.

The results for all trades displayed in the first row of Table 5 show that average daily performance is higher during the BPS sample period ending in June 2021. Specifically, average daily gross and net performance are \$3.59 million (t -statistic 2.07) and \$2.07 million (t -statistic 1.19), respectively, compared to \$1.57 million and \$0.34 million for the sample period ending in June 2023. Consistent with the results in Table 4, the overall performance is driven primarily by call buys, and secondarily by put sells. The average gross and net performance of call buys are \$5.87 (t -statistic 3.03) and \$4.99 (t -statistic 2.44), respectively. The same averages for sales of puts

are \$1.33 (*t*-statistic 1.38) and \$1.17 (*t*-statistic 1.13). Call sells and put buys are not profitable during this sample period, consistent with the results in Table 4.

The net performance estimates displayed in Tables 4 and 5 contrast with those reported by BPS using a sample of SLIM trades executed on all exchanges that offer the SLIM trade protocol. BPS' estimate of the average daily net performance of SLIM trades in equity and ETF options held to expiration that they report in their Table VI is $-\$1.63$ million (*t*-statistic -0.39). This contrasts with our results for all trades, which show positive performance. We find that call trades held to expiration are profitable, while BPS find that they are not. BPS also find that average daily net performance is negative, larger in magnitude, and statistically significant at the intraday, one-day, two-day, five-day, and ten-day horizon they consider, and conclude that "these [SLIM] trades lose money for all horizons considered" (BPS, p. 3468).

The BPS analysis suffers from two limitations of the OPRA trade data they use. First, the BPS data do not include the trade directions (buy or sell); instead, BPS must estimate trade direction using a version of the quote rule. This is an important reason why their results contrast with ours.¹⁰ The BPS results are also impacted by choices about how to compute profitability at different horizons that we find surprising.

The next section of this paper explores the extent to which the BPS choices that we find surprising impact their performance estimates, and how the performance estimates change when we make choices that we consider more reasonable. Section 5 then explores how the estimates are impacted by using the correct trade directions.

4. Impact of Choices Made by BPS

BPS report gross and net performance results for an intraday horizon, horizons of one, two, five, and ten days, and through the expiration of the options, whenever that might be (BPS Table VI). The sample consists of all SLIM trades of stock and ETF options that expire on or before December 31, 2021 executed on any options exchange during the sample period running from November 4, 2019 through June 2021. BPS assume that all trades are opening trades and options are held to expiration. Gross performance is the average daily profit of options trades executed on each day, where the initial price used to compute the profit on each trade is the

¹⁰ As discussed in Section 3.1, knowledge of which trades are closing trades is not needed to compute the profitability of all trades (both buys and sells) over the trades' entire lives. But it does make it impossible to separately compute the profitability of buys or sells, or to compute profitability over any horizon other than the trades' entire life cycles.

midpoint of the NBBO quotes attached to the trade record and commissions and other costs are not included. Net performance is computed using the actual trade prices. In both cases, the final value of the option used to compute the profit is “the last available price when the data for a certain horizon are not available” (BPS fn. 35).

4.1 Replication of performance results in BPS Table VI

We replicate the net performance results in BPS Table VI using our OPRA trade data and report the results in Table 6.¹¹ As expected, the results in Table 6 resemble the corresponding results in BPS Table VI. The results in both tables show that, for the sample of all trades, gross performance is positive and net performance is negative for all horizons considered. The results agree that gross performance is statistically significantly different from zero for all horizons and net performance is statistically significantly negative for all horizons other than expiry, where it is negative but insignificant. The two tables also display the same patterns in the performance by trade direction and contract type (put or call).

The values displayed in the two tables, while not identical, are similar. For example, for the sample of all trades, BPS compute average daily net performance of -4.92 , -3.52 , -4.47 , -4.80 , -5.03 , and -1.63 million dollars for the intraday horizon, one, two, five, and ten days, and through expiration. The corresponding results in Table 6 are -4.52 , -3.23 , -4.23 , -4.72 , -4.96 , and -1.75 million dollars.

4.2 Impact of using “the last available [midpoint] price”

In computing performance, BPS “use the last available [midpoint] price when the data for a certain horizon are not available” (fn. 35). While at first glance this might seem like a reasonable approach, we do not agree that it is.

At the horizons of one, two, five, and ten days, the prices of options that expire before the end of the horizon are not available on the last day of the horizon. For example, for the ten-day horizon, options that expire on days zero through nine do not have price data on day ten; rather, “the last available price” is from the earlier expiration date of the option. BPS do not exclude these earlier-expiring options from the calculation of the profits for the ten-day horizon, but instead include the profits on these earlier-expiring options in the profit for the ten-day horizon, using “the

¹¹ BPS obtain the OPRA trade data from Cboe Livevol, while we obtain our trade data from Algoseek LLC. We have no reason to doubt that the data are the same.

last available price” to compute the profits. As a result, the profits for the ten-day horizon include the profits on options that did not exist for the entire horizon. Some of these options will have expired up to nine days earlier. The BPS profitability results for the one-, two-, and five-day horizons similarly include the profits of the options that expired before the end of the horizon. This approach might provide a misleading impression of the profitability of options trades at horizons of between one and ten days.

BPS also use “the last available [midpoint] price” (fn. 35) in their trade data as the value of an expiring option.¹² That is, rather than using the per-share expiration value of $\max(S - K, 0)$ for a call or $\max(K - S, 0)$ for a put, they use the midpoint of the NBBO prices attached to the last trade record within the horizon. For example, if an option expires during the five-day horizon, rather than using the expiration value they use the NBBO midpoint at the time of the last trade during the five-day horizon. When they compute profits of options held to expiration, they do not use the expiration values but rather use the last trade price prior to expiration.

This approach results in two biases. First, because the NBBO midpoint is strictly positive, the approach overstates the expiration values of options that expire out-of-the-money (OTM). This will overstate (understate) the performance of purchased (sold) options that expire OTM. Second, quote midpoints of well in-the-money (ITM) options tend to be below the options’ exercise values (Battalio, Figlewski, and Neal, 2020). Thus, it is likely that the midpoints of the NBBO prices attached to the trade records of such options also tend to be below the options’ exercise values. The net effect of these biases depends on the mix of purchased and written positions, and the fractions of them that expire OTM and ITM. It is also possible that the BPS approach biases the profit calculation for options that expire slightly ITM, though the direction and magnitude of such a bias is not clear.

We examine the impact of these biases by repeating the Table 6 analysis, but using the per-share expiration values $\max(S - K, 0)$ and $\max(K - S, 0)$ of calls and puts that expire during the return horizons in place of the NBBO midpoint prices at the time of the last trade. We also exclude the gains on the options that expire before the last day of the horizon from the results for the one-, two-, five-, and ten-day horizons. The results show better performance for the full sample of all contracts and the subsamples of calls and puts held through expiration. For the sample of trades in

¹² Although fn. 35 does not make this entirely clear, examination of the BPS replication package reveals that they use the midpoint prices in place of the expiration values of the options.

all contracts, using the expiration values rather than the NBBO midpoint at the time of the last trade changes the gross (net) performance through expiration from \$9.63 (–\$1.75) million per day in Table 6 to \$11.71 (\$0.36 million) million per day in Table 7. The net performances of call and put trades held to expiration also switch from negative to positive, with the average daily performance of call (put) trades increasing from –\$1.48 to \$0.24 (–\$0.27 to \$0.12) per day. The changes in the net performance of the samples of all trades and call trades at the five- and ten-day horizons are large, though not large enough to change the performance from negative to positive.

The results in Panel B in which trades are categorized by direction (buy or sell) show that buys have positive performance on average, and sells do not. The results in Panel D in which trades are categorized by both direction and type (call/put) also show that call buys and put sells have positive performance, while call sells and put buys are not. Thus, the trades that provide positive exposure to stock prices, call buys and put sells, show positive performance, while the trades that provide negative exposure to stock prices, call sells and put buys, are unprofitable. This is what one would expect, given that stock prices, as measured by the broad market indexes, were higher at the end of June 2021 than at the beginning of November 2019.

The results displayed in Panel D also help understand how our approach of using the exercise values of options held to expiration versus the BPS approach of using the midpoint of the last trade can change the estimate of the net performance of options held to expiration from –\$1.75 million in Table 6 Panel A to \$0.36 million in Table 7 Panel A. The difference between these two estimates is \$2.11 million. In Table 7 Panel D, the estimates of the net performance of purchased and sold calls held to expiration are \$115.18 million and –\$116.66 million, while those of purchased and sold puts are –\$49.56 and \$49.68. Relatively small percentage changes in these performance measures will exceed \$2.11 million. In fact, the net performance of purchased (sold) calls changed by \$12.78 (–\$11.06) million from Table 6 Panel D to Table 7 Panel D, and the net performance of purchased (sold) puts changed by –\$1.95 (\$2.34) million.

5. Impact of Using the Correct Trade Direction

The OPRA trade data BPS use do not include the trade direction (buy or sell) of the trades. BPS follow Muravyev (2016) and estimate the trade direction of each trade using a version of the quote rule. They first compare the trade price to the midpoint of the NBBO quotes attached to the trade record, and sign a trade as a buy (sell) if the trade price is above (below) the NBBO midpoint.

If the trade price is equal to the NBBO midpoint, they look to the BBO midpoint on the exchange on which the trade occurred, and sign the trade as a buy (sell) if the trade price is above (below) the BBO midpoint. Both the NBBO and BBO midpoints equal the trade price for about 2% of trades (Table 1), and these trades are left unsigned. In contrast, the Cboe data we use include the correct trade directions. In this section we examine the impact of using the correct trade direction and show that the performance estimates differ considerably depending on whether one uses the correct trade direction or estimates trade direction using the quote rule.

Our analysis of the impact of the trade direction on profits is restricted to the Cboe data, because we have the correct trade directions only for the Cboe data.

This raises the question, are Cboe SLIM trades similar to SLIM trades executed on other exchanges? The results in Table 1 show that the characteristics of Cboe SLIM trades displayed in that table closely resemble the characteristics of SLIM trades executed on other exchanges. We now turn to examine whether the patterns in the performance of SLIM trades executed on the Cboe exchanges resemble the patterns in the performance of the SLIM trades executed on all exchanges. We hope to see similar patterns in performance, taking account of the fact that the Cboe SLIM trading volume is 27.5% % of total options trading volume. These analyses sign trades as in BPS, because we do not know the correct trade directions of the trades on the non-Cboe exchanges.

After we do this, the next step is to compare the performance estimates of the Cboe SLIM trades based on the BPS trade signing to performance estimates of the Cboe SLIM trades that use the correct trade directions. Because we have the Cboe data starting in January 2020, we will do this comparison using samples that start in January 2020. To allow comparison to all SLIM trades, we also analyze the performance of all SLIM trades using the same sample period.

5.1 Does the performance of the Cboe SLIM trades resemble that of all SLIM trades?

We report estimates of the performance of all SLIM trades in Table 8. For this analysis, we use the BPS approach to estimate trade direction, and apply the same adjustments to the BPS approach that we made for Table 7. Specifically, we follow BPS, except that: (i) we exclude options that have previously expired from the results for the one-, two-, find-, and ten-day horizons; and (ii) for expiring options, we use the per-share expiration values of $\max(S - K, 0)$ and $\max(K - S, 0)$ as the final values of the calls and puts, respectively, rather than the NBBO midpoints at the time of the last trade used by BPS. The sample consists of SLIM trades of stock and ETF options that expire before or during December 2021 executed on any options exchanges during the sample

period running from January 2020 through June 2021. Thus, the analysis is the same as that reported in Table 7, with the only difference being that the sample begins in January 2020 rather than November 4, 2019.

We carry out the same analysis of the Cboe SLIM trades, and report the results in Table 9. The sample consists of customer SLIM trades in options that expire by the end of December 2021 executed on one of the Cboe exchanges during the period running from January 2020 through June 2021.

Tables 8 and 9 display similar performance patterns. Comparing the results in Table 9 Panel A to the corresponding results in Table 8, in both tables gross performance is positive at all horizons, largest for options held to expiration, and second largest at the one-day horizon. At each horizon, the ratios of the gross performance of the Cboe SLIM trades to the gross performance of all SLIM trades range from 25% to 37%. Recognizing that there is considerable sampling variation in both estimates, these ratios are consistent with the Cboe's 27.5% share of total SLIM trading volume.

Net performance is negative at all horizons, with the exception that the performance at the ten-day horizon is positive for Cboe SLIM trades (Table 9) and negative for all SLIM trades (Table 8). However, neither of these estimates at the 10-day horizon is statistically significant. In both tables, net performance is worst, and highly statistically significant, at the intraday horizon. Net performance is not significantly different from zero at the five- and ten-day horizons in either table, or if options are held to expiration.

Panels B-D show the gross and net performance of trades categorized by trade direction (buy/sell), contract type (call/put), and both trade direction and contract type. Comparison of the results in these panels across Tables 8 and 9 also shows similar patterns in performance. These results, together with those in Table 1, suggest that it is reasonable to extrapolate our results for Cboe SLIM trades to trades executed on other exchanges.

5.2 Performance estimates using the correct trade direction

We now turn to the question of whether BPS' use of estimates of trade direction has an important impact on the estimates of the performance of customer SLIM trades. We first compute the performance of Cboe customer SLIM trades estimating the trade direction using the approach of BPS, and report the results in Table 10. The sample consists of customer SLIM trades in options

that expire by the end of December 2021 executed on one of the Cboe exchanges during the period running from January 2020 through June 2021.

Because most Cboe SLIM trades are customer trades (Table 2), one should expect that the performance estimates resemble those for all SLIM trades in Table 9, and they do. For example, in the sample of all trades the net performance if options are held to expiration in Table 10 Panel A is $-\$0.28$ million per day. The corresponding estimate in Table 9 Panel A is $-\$0.29$ million per day.

We report the estimates of performance based on the correct trade directions in Table 11. Comparing the results displayed Panel A of Table 11 to the corresponding estimates in Table 10, both gross and net performance increase at all horizons. The performance estimate in the sample of all trades (Panel A) when trades are held to expiration is now $\$2.07$ million per day, which matches the estimate for all trades in Table 5, as it must. This is noticeably different from the corresponding estimate of $-\$0.28$ million per day for the sample of all trades reported in Panel A of Table 10 based on estimated trade directions. For “All trades” (Panel A), the estimate of gross profitability of trades held to expiration changes from $\$2.69$ million per day in Table 10 to $\$3.59$ million per day in Table 11. Because the performance estimates for other horizons do not take account of closing trades, the performance estimates for trades held to expiration are the most meaningful estimates of performance. Thus, using the correct trade direction results in the most meaningful estimates of performance switching from negative to positive.

The result that the performance estimates for “All trades” increase when the correct trade direction is used is not guaranteed to occur, but should not be surprising. BPS sign trades using a version of the quote rule. With this approach, a trade near the offer is signed as a buy, and a trade near the bid is signed as a sell. If the midpoint is treated as an estimate of fair value and is used as a benchmark, then these two trades are treated as a buy and a sell executed at unfavorable prices, relative to the midpoint. But using the correct trade direction, they are a sell and a buy, executed at favorable prices relative to the midpoint. This is a generic issue with the quote rule—trades are signed based on the assumption that all trades are executed at prices less favorable than the midpoint. (Midpoint trades are not signed.) Absent correlation between the errors in estimating trade direction and trade performance, using the quote rule will tend to understate profitability.

This conclusion need not hold if there is an important correlation between the errors in estimating trade direction and trade performance. For example, suppose customer sells near the offer and buys near the bid tend to be unprofitable, perhaps because those trades tend to be executed when the trade counterparties have relevant information indicating that the trades will be profitable to the counterparties and thus unprofitable to the customers. In this case, incorrectly signing the unprofitable sells turns them into trades that seem like profitable buys, and incorrectly signing the unprofitable buys turns them into trades that seem like profitable sells. This, or something similar, appears to be happening with the put trades. Comparison of the rows labelled “Put” in Panels A of Table 10 and Table 11 shows that the change from using the quote rule to the correct trade direction reduces the profitability of the put trades.

6. Conclusion

Several recent papers use proxies for retail options trading to study its profitability (BPS, Silva, Smith, and So (2022), Naranjo, Nimalendran, and Wu (2024), Beckmeyer, Branger, and Gayda (2023), Muravyev and Bogousslavsky (2024)). Based on the samples and proxies they use, they conclude that retail investors generally lose money trading options. We focus on the analysis of BPS, because their sample seems to be most representative of retail options trading, and their paper has received the most attention.

In contrast to BPS, we find that the net performance of customer SLIM trades executed on one of the two Cboe exchanges that offer SLIMs (CBOE and EDGX) was positive, though not statistically significant. We obtain this result by exploiting data on trades executed on the Cboe exchanges that cover the period running from January 2020 through June 2023 that we obtain from Cboe Global Markets. These data include the trading capacities of the trade counterparties, the channel on which the trade is executed, which party bought and which sold, and, for the non-market maker capacities, whether the trade was an opening or a closing trade. We estimate the average net performance of Cboe customer SLIM trades to be \$0.34 million per day during January 2020 through June 2023 sample period, and \$2.07 million per day during the January 2020-June 2021 sample period. This latter sample period matches the BPS November 2019-June 2021 sample period except that it does not include the first two months of the BPS sample period.

We identify two reasons that explain why we find overall positive net performance of trades held to expiration while BPS find overall negative net performance. First, rather than computing the gain or loss on an expiring option as the difference between the expiration value

and the purchase price, they compute it as the difference between the NBBO midpoint at the time of the last trade prior to expiration and the purchase price. In their sample, when we use the expiration values to compute performance, the average performance of options held to expiration improves by \$2.11 million per day, changing from $-\$1.75$ million per day to $\$0.36$ million per day.

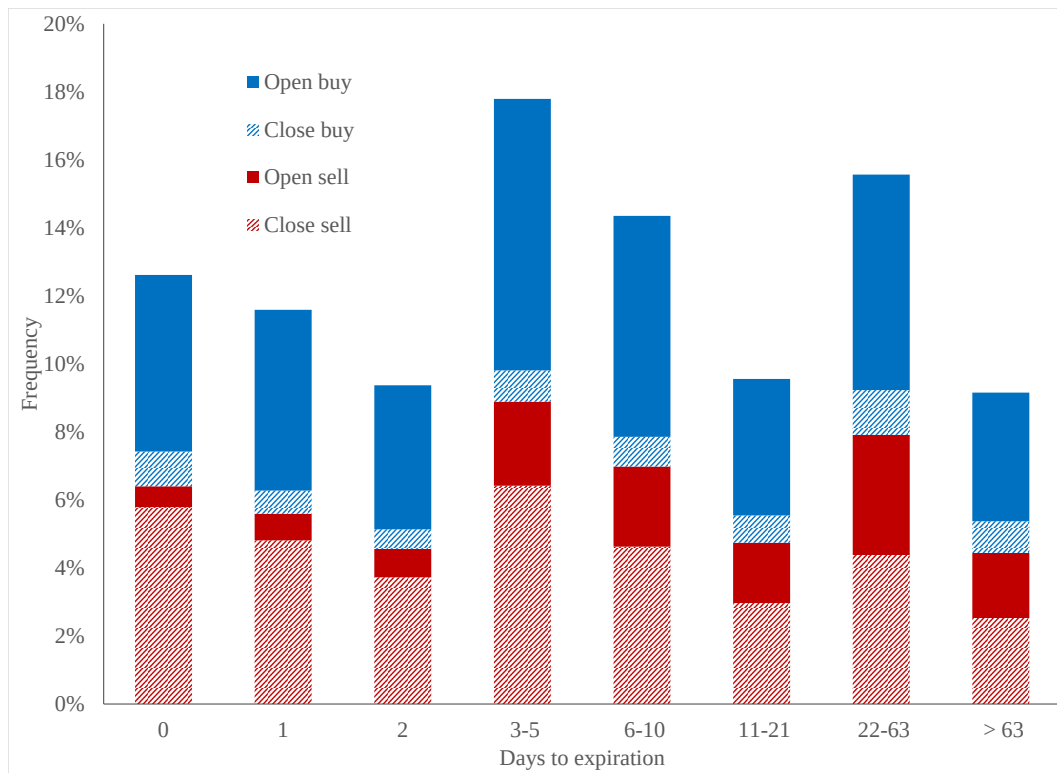
Second, the OPRA data BPS use do not include the trade direction (buy/sell), forcing BPS to estimate trade direction using a version of the quote rule. To study the impact of trade direction, we compute estimates of customer profits in two different ways, using (i) the quote rule used by BPS and (ii) the correct trade direction. Based on the quote rule, the results show customer losses at all horizons except for ten days. The losses at the intraday horizon are large ($\$1$ million per day), and highly statistically significant, and the losses at the one-day horizon are significant at the 10% level. Using the correct trade direction, the results show losses at only two horizons, intraday and two days, and only the loss at the intraday horizon is statistically significant. The performance assuming options are held to expiration are large, $\$2.07$ million per day, though not statistically significant.

References

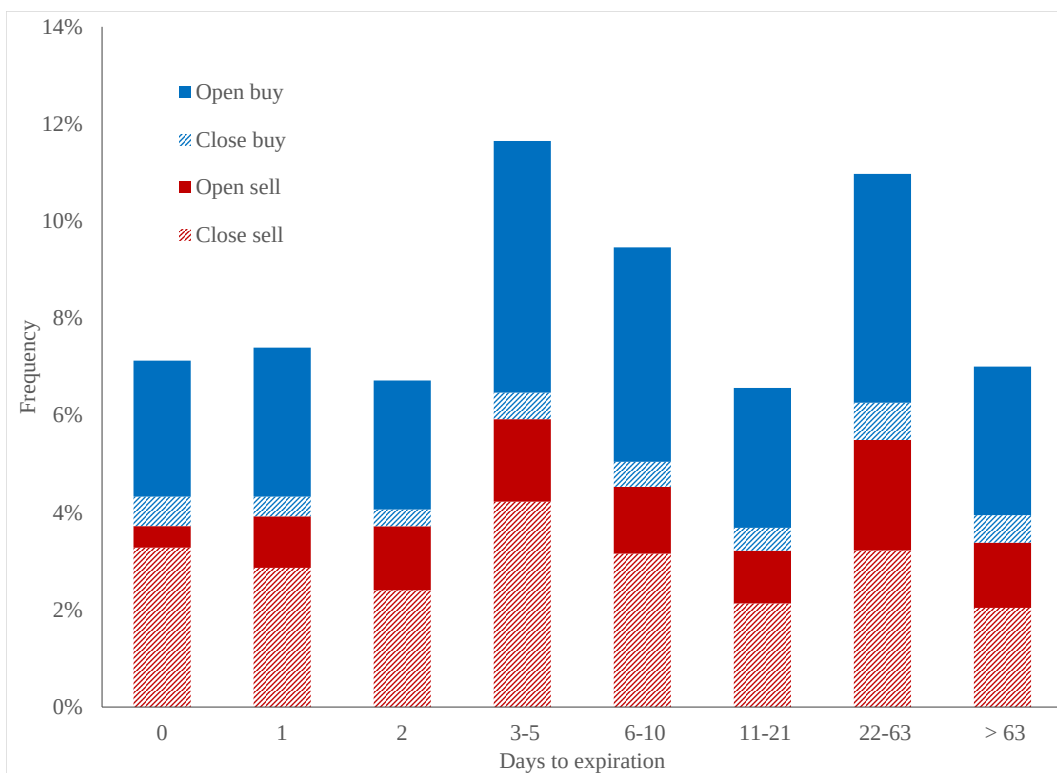
- Battalio, Robert, Stephen Figlewski, and Robert Neal, 2020. Option investor rationality revisited: The role of exercise boundary violations. *Financial Analysts Journal* 76 (1), 82–99.
- Bauer, Rob, Mathijs Cosemans, and Piet Eichholtz, 2009. Option trading and individual investor performance, *Journal of Banking & Finance* 33, 731–746.
- Beckmeyer, Heiner, Nicole Branger, and Leander Gayda, 2024. Retail traders love Otdte options... but should they? Working paper, University of Munster.
- Boehmer, Ekkehart, Charles M. Jones, Xiaoyan Zhang, and Xinran Zhang, 2021. Tracking retail investor activity. *Journal of Finance* 76, 2249–2305.
- Bogousslavsky, Vincent, and Dmitriy Muravyev, 2025. An anatomy of retail option trading. Working paper, Boston College.
- Boyer, Brian H., and Keith Vorkink, 2014. Stock options as lotteries. *Journal of Finance* 69, 1485–1527.
- Bryzgalova, Pavlova, Sikorskaya. 2023. Retail Trading in Options and the Rise of the Big Three Wholesalers. *Journal of Finance* 87, No. 6, 3465–3514.
- de Silva, Tim, Kevin Smith, and Eric C. So, 2022. Losing is optional: Retail option trading and earnings announcement volatility. Working paper, MIT.
- Eaton, Gregory W., T. Clifton Green, Brian S. Roseman, and Yanbin Wu, 2022a. Retail trader sophistication and stock market quality: Evidence from brokerage outages. *Journal of Financial Economics* 146, 502–528.
- Eaton, Gregory W., T. Clifton Green, Brian Roseman, and Yanbin Wu, 2022b. Retail option traders and the implied volatility surface, Working paper, Emory University.
- Ernst, Thomas, and Chester S. Spatt, 2022. Payment for order flow and asset choice. NBER Working Paper 29883.
- Fedyk, Valeria, 2021. This time is different: Investing in the age of Robinhood. Working paper, London Business School.
- Han, Selina. 2024. Unveiling the sophistication: Understanding retail investors' trading behavior in the U.S. options market. Working paper, Cboe Global Markets
- Hendershott, Terrence J., Saad Khan, and Ryan Riordan, 2024. Option auctions. Working paper, University of California, Berkeley.
- Jones, Charles M., Adam V. Reed, and William Waller, 2021. When brokerages restrict retail investors, does the game stop? Working paper, Columbia University.

- Jones, Charles M., Xiaoyan Zhang, and Xinran Zhang, 2022. Retail investors in the pandemic. Working paper, Columbia University.
- Lakonishok, Josef, Inmoo Lee, Neil D. Pearson, and Allen M. Poteshman, 2007. Option market activity. *Review of Financial Studies* 20, 813–857.
- Lee, Charles M. C. and Mark J. Ready, 1991. Inferring trade direction from intraday data. *Journal of Finance* 46, 733–746.
- Merton, Robert C., 1980. On estimating the expected return on the market: An exploratory investigation. *Journal of Financial Economics* 8, 323–361.
- Naranjo, Andy, Mahendrarajah Nimalendran, and Yanbin Wu. 2024. Betting on elusive returns: Retail trading in complex options. Working paper, University of Florida.
- Savickas, Robert, and Arthur J. Wilson, 2003. On inferring the direction of option trades. *Journal of Financial and Quantitative Analysis* 38, 881–902.

Panel A. Call and put trades



Panel B. Call trades



Panel C Put trades

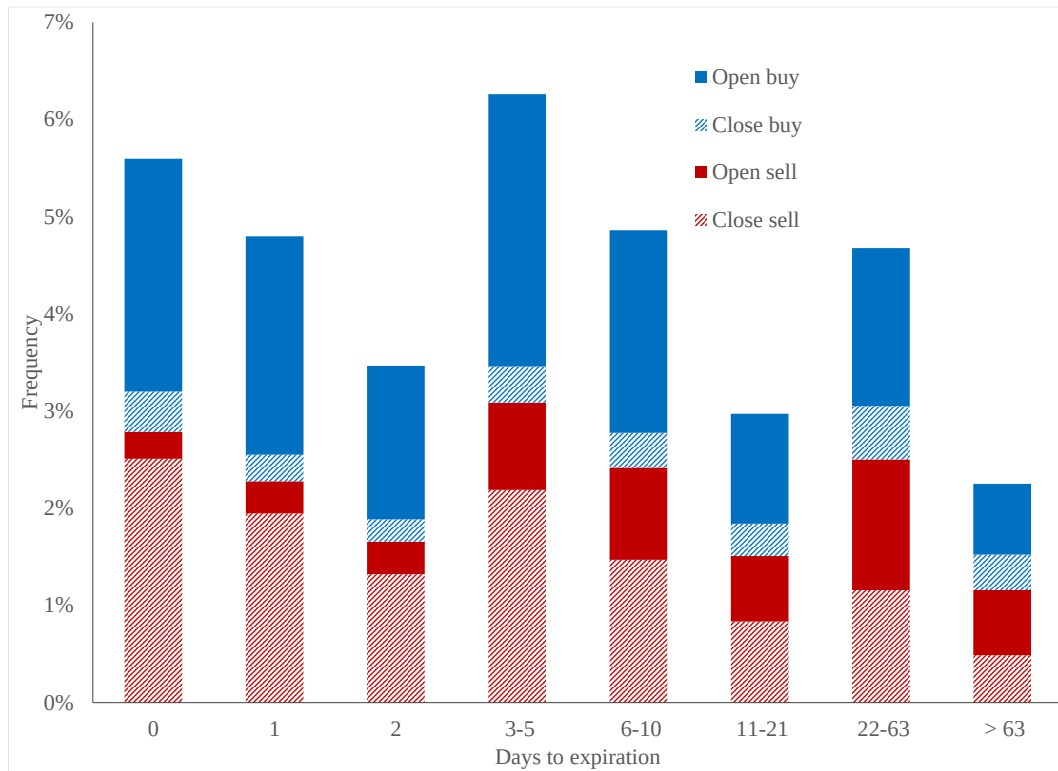


Figure 1

Prevalence of opening and closing SLIM buys and sells

This figure displays the prevalence of opening and closing SLIM buys and sell trades in options with differing times to expiration. Trades are sorted into buckets defined by the options time to expiration, using the buckets 0, 1, 2, 3-5, 6-10, 11-21, 22-63, and greater than 63 days to expiration. For each bucket, we compute the ratio of the number SLIM trades in options in that bucket to the total number of SLIM trades during the sample period, and display the results in the form of a stacked bar chart. The solid (striped) blue bars show the results for opening (closing) buys in each bucket, and the solid (striped) red bars show results for opening (closing) sells. Panels A, B, and C display the results for both call and put trades, call trades, and put trades, respectively. The sample consists of Cboe SLIM trades executed during the period running from January 2020 through June 2023.

Table 1**Characteristics of Cboe and non-Cboe SLIM trades**

This table reports characteristics of Cboe and non-Cboe SLIM trades by category. The sample period runs from January 2021 through June 2021. (Implied) Trade direction is based on whether the trade price is above (buy) or below (sell) the NBBO midpoint, or if equal the the NBBO midpoint, the BBO midpoint on the exchange where the trade occurred. If the trade price, NBBO midpoint, and BBO midpoint are equal, then the trade is a midpoint trade. Quoted spread is the spread between the national best bid and offer, divided by the midpoint price at the time of the trade. effective spread is the signed difference between the trade price and the NBBO midpoint computed from the quotes attached to the trade records, multiplied by two and divided by the midpoint. For both spreads, we report frequency-weighted averages. Moneyness for calls is measured as $(\text{MidpointPrice} - \text{Strike})/\text{Strike}$, with the opposite sign for puts.

Characteristic	Category	Cboe exchanges				Non-Cboe exchanges			
		Trade share	Volume share	Quoted spread	Effective spread	Trade share	Volume share	Quoted spread	Effective spread
Type	Call	70.69%	68.40%	13.90%	6.07%	69.94%	68.44%	14.02%	6.57%
	Put	29.31%	31.60%	14.12%	6.36%	30.06%	31.56%	13.86%	6.54%
Direction (all)	Sell	50.59%	49.97%	14.08%	6.45%	50.07%	49.67%	13.95%	6.81%
	Buy	46.12%	47.51%	13.22%	6.04%	47.16%	47.96%	12.95%	6.40%
	Midpoint	3.29%	2.53%	15.32%	0.00%	2.78%	2.37%	21.71%	0.00%
Direction (calls)	Sell	35.56%	34.00%	14.15%	6.41%	34.79%	33.79%	14.14%	6.87%
	Buy	32.92%	32.76%	13.44%	6.09%	33.22%	33.05%	13.38%	6.63%
	Midpoint	2.21%	1.64%	16.10%	0.00%	1.93%	1.59%	22.94%	0.00%
Direction (puts)	Sell	15.03%	15.97%	14.74%	6.95%	15.28%	15.88%	14.46%	7.14%
	Buy	13.20%	14.74%	13.38%	6.22%	13.94%	14.91%	12.81%	6.30%
	Midpoint	1.08%	0.89%	14.38%	0.00%	0.85%	0.78%	19.85%	0.00%
Trade size (contracts)	1	46.13%	6.45%	13.61%	5.46%	46.08%	6.78%	13.87%	6.12%
	2 to 5	30.32%	13.38%	12.88%	5.64%	31.06%	14.20%	12.75%	6.04%
	6 to 10	11.69%	14.21%	14.52%	6.87%	11.66%	15.21%	14.16%	7.06%
	11 to 100	11.37%	57.42%	15.45%	8.39%	10.71%	54.79%	14.96%	7.99%
	Above 100	0.63%	10.76%	17.22%	12.76%	0.62%	11.36%	14.79%	10.67%
Trade size (dollars)	Below 250	39.46%	14.91%	23.68%	10.84%	42.29%	15.26%	23.62%	11.42%
	250-500	15.51%	9.30%	9.85%	4.05%	15.63%	9.34%	8.42%	3.78%
	500-1000	14.10%	11.74%	8.24%	3.30%	13.59%	11.78%	7.09%	3.08%
	1000-2500	14.42%	17.81%	6.81%	2.66%	13.44%	17.77%	5.92%	2.50%
	2,500-5,000	7.41%	13.82%	5.55%	2.13%	6.74%	13.64%	4.94%	2.04%
	5,000-10,000	4.93%	13.19%	4.59%	1.75%	4.50%	13.07%	4.18%	1.71%
	10,000-20,000	2.53%	9.95%	4.05%	1.55%	2.30%	9.83%	3.74%	1.53%
	20,000-50,000	1.28%	6.59%	3.60%	1.36%	1.17%	6.68%	3.34%	1.35%
	Above 50,000	0.38%	2.68%	3.02%	1.15%	0.34%	2.63%	2.89%	1.18%

Table 1 (continued)

Characteristic	Category	Cboe exchanges				Non-Cboe exchanges			
		Trade share	Volume share	Quoted spread	Effective spread	Trade share	Volume share	Quoted spread	Effective spread
Time to expiry (days)	0	13.78%	17.71%	11.70%	7.06%	13.28%	16.39%	10.59%	6.28%
	1	22.32%	25.16%	8.71%	4.77%	22.31%	24.36%	8.11%	4.48%
	2 to 5	26.04%	24.99%	7.74%	3.96%	26.50%	25.55%	7.42%	3.98%
	6 to 10	14.89%	13.85%	9.59%	4.33%	15.68%	14.49%	9.29%	4.49%
	11 to 20	9.84%	9.37%	13.17%	5.46%	10.31%	9.83%	12.98%	5.79%
	21 to 30	8.97%	8.57%	15.11%	5.94%	8.95%	8.63%	15.50%	6.57%
	31 to 60	11.17%	10.97%	14.38%	5.68%	10.90%	10.88%	14.75%	6.17%
	61 to 90	3.44%	3.47%	12.90%	5.00%	3.24%	3.38%	13.70%	5.56%
	91 to 180	5.07%	4.92%	16.82%	6.31%	4.64%	4.76%	18.52%	7.02%
	180 to 360	2.71%	2.40%	21.15%	8.26%	2.23%	2.18%	21.84%	8.23%
	> 360	0.32%	0.24%	14.36%	5.00%	0.28%	0.23%	19.10%	7.53%
Moneyness	Below -2	0.20%	0.21%	61.84%	29.12%	0.21%	0.21%	66.79%	32.74%
	from -2 to -1	0.32%	0.37%	52.80%	24.20%	0.34%	0.37%	57.13%	26.79%
	from -1 to -0.1	22.88%	24.07%	28.10%	12.63%	23.65%	24.18%	29.49%	13.73%
	At the money	72.05%	71.50%	9.23%	4.02%	71.69%	71.52%	8.60%	4.07%
	from 0.1 to 1	4.38%	3.71%	9.14%	3.46%	3.95%	3.59%	8.77%	3.54%
	from 1 to 2	0.12%	0.10%	10.26%	3.50%	0.12%	0.10%	9.49%	3.27%
	Above 2	0.05%	0.03%	9.84%	3.11%	0.05%	0.03%	9.56%	2.97%

Table 2**Fractions of SLIM trading volume due to each trading capacity**

This table shows the percentages of SLIM trading volume on the Cboe exchanges that offer a SLIM due to the buys and sells of each trading capacity. Each entry displays the percentage of total volume due to buys by the trading capacity indicated in the row label and sells by the capacity indicated in the column heading. The sample period is January 2020 through June 2023. Percentages do not sum to 100% because there are a small number of trades executed by traders in capacities not included in the table.

Panel A. CBOE

		SLIM sells					
		Customer	Market maker	Firm	Prof. custom.	Broker-dealer	Sum
SLIM buys	Customer	0.57%	46.73%	2.65%	0.24%	0.01%	50.20%
	Market maker	46.97%	0.00%	0.02%	0.04%	0.00%	47.03%
	Firm	2.23%	0.01%	0.01%	0.02%	0.00%	2.27%
	Prof. Custom.	0.31%	0.06%	0.04%	0.00%	0.00%	0.41%
	Broker-dealer	0.02%	0.00%	0.00%	0.00%	0.00%	0.03%
	Sum	50.11%	46.80%	2.71%	0.30%	0.02%	99.94%

Panel B. EDGX

		SLIM sells					
		Customer	Market maker	Firm	Prof. custom.	Broker-dealer	Sum
SLIM buys	Customer	0.60%	46.43%	1.68%	0.18%	1.14%	50.02%
	Market maker	46.67%	0.00%	0.01%	0.28%	0.02%	46.98%
	Firm	1.34%	0.00%	0.00%	0.02%	0.01%	1.37%
	Prof. Custom.	0.15%	0.24%	0.05%	0.00%	0.06%	0.49%
	Broker-dealer	0.89%	0.01%	0.01%	0.02%	0.00%	0.92%
	Sum	49.65%	46.67%	1.75%	0.49%	1.23%	99.79%

Table 3**Fractions of electronic LOB trading volume due to each trading capacity**

This table shows the percentages of electronic trading volume on the Cboe exchanges due to the buys and sells of each trading capacity. Each entry displays the percentage of total volume due to buys by the trading capacity indicated in the row label and sells by the capacity indicated in the column heading. The sample period is January 2020 through June 2023. Percentages do not sum to 100% because there are a small number of trades executed by traders in capacities not included in the table.

Panel A. CBOE

		Electronic sells					
		Customer	Market maker	Firm	Prof. custom.	Broker-dealer	Sum
Electronic buys	Customer	5.00%	34.92%	0.22%	0.40%	0.01%	40.56%
	Market maker	39.81%	9.31%	1.75%	1.40%	0.20%	52.46%
	Firm	0.19%	3.01%	0.06%	0.02%	0.02%	3.30%
	Prof. Custom.	0.41%	1.68%	0.01%	0.03%	0.00%	2.13%
	Broker-dealer	0.02%	0.23%	0.01%	0.00%	0.14%	0.40%
	Sum	45.43%	49.15%	2.05%	1.85%	0.38%	98.85%

Panel B. EDGX

		Electronic sells					
		Customer	Market maker	Firm	Prof. custom.	Broker-dealer	Sum
Electronic buys	Customer	4.08%	42.34%	0.05%	0.19%	0.01%	46.67%
	Market maker	42.23%	7.13%	0.95%	0.47%	0.11%	50.89%
	Firm	0.04%	1.27%	0.00%	0.00%	0.00%	1.31%
	Prof. Custom.	0.16%	0.64%	0.00%	0.00%	0.00%	0.80%
	Broker-dealer	0.01%	0.11%	0.00%	0.00%	0.00%	0.11%
	Sum	46.51%	51.49%	1.00%	0.67%	0.12%	99.79%

Panel C. C2

		Electronic sells					
		Customer	Market maker	Firm	Prof. custom.	Broker-dealer	Sum
Electronic buys	Customer	1.21%	31.49%	0.04%	0.15%	0.01%	32.90%
	Market maker	32.35%	20.43%	2.33%	2.37%	0.73%	58.21%
	Firm	0.04%	2.82%	0.01%	0.02%	0.00%	2.89%
	Prof. Custom.	0.14%	2.37%	0.02%	0.05%	0.03%	2.60%
	Broker-dealer	0.01%	0.83%	0.00%	0.02%	0.00%	0.87%
	Sum	33.75%	57.94%	2.39%	2.62%	0.77%	97.47%

Table 3 (continued)

Panel D. BATS

		Electronic sells					Sum
		Customer	Market maker	Firm	Prof. custom.	Broker- dealer	
Electronic buys	Customer	4.26%	46.37%	0.07%	0.42%	0.02%	51.14%
	Market maker	48.09%	0.00%	0.00%	0.00%	0.00%	48.09%
	Firm	0.07%	0.00%	0.00%	0.00%	0.00%	0.07%
	Prof. Custom.	0.35%	0.00%	0.00%	0.00%	0.00%	0.35%
	Broker-dealer	0.02%	0.00%	0.00%	0.00%	0.00%	0.02%
	Sum	52.79%	46.37%	0.07%	0.42%	0.02%	99.67%

Table 4**Gross and net profitability of customer SLIM trades, Jan. 2020-June 2023**

This table shows the average daily gross and net profitability of Cboe customer SLIM trades, in millions of dollars, taking account of closing trades using the approach described in Section 3.1. The sample consists of all trades in equity and ETF options that expire by the end of August 2023 that were executed during the period running from January 2020 through June 2023. The final values of the options are the exercise values. Gross profitability is computed assuming that the trade price equals the NBBO midpoint at the time of the trade. Net profitability is computed using the actual trade prices. t-statistics are in parentheses below the estimates.

	Gross performance			Net performance		
	Opening trades, assuming held to expiration	Adjustment for closing trades	Profitability after adj. for closing trades	Opening trades, assuming held to expiration	Adjustment for closing trades	Profitability after adj. for closing trades
All trades			1.57 (1.32)			0.34 (0.29)
Open sells & close buys	-2.29 (-1.83)	2.26 (2.12)	-0.03 (-0.05)	-2.57 (-2.04)	2.21 (2.07)	-0.35 (-0.60)
Open buys & close sells	8.85 (1.57)	-7.25 (-1.52)	1.60 (1.23)	8.43 (1.50)	-7.74 (-1.62)	0.69 (0.54)
Call trades			2.29 (1.85)			1.44 (1.17)
Call open sells & close buys	-3.57 (-2.84)	3.05 (2.78)	-0.52 (-0.95)	-3.72 (-2.96)	3.02 (2.75)	-0.70 (-1.29)
Call open buys & close sells	14.45 (2.28)	-11.65 (-2.22)	2.80 (2.04)	14.14 (2.23)	-12.00 (-2.29)	2.14 (1.57)
Put trades			-0.72 (-1.51)			-1.10 (-2.31)
Put open sells & close buys	1.28 (1.33)	-0.79 (-1.14)	0.49 (0.89)	1.16 (1.20)	-0.81 (-1.17)	0.35 (0.63)
Put open buys & close sells	-5.60 (-1.57)	4.39 (1.39)	-1.21 (-2.08)	-5.71 (-1.60)	4.26 (1.35)	-1.45 (-2.50)

Table 5**Gross and net profitability of customer SLIM trades, Jan. 2020 - June 2021**

This table shows the average daily gross and net profitability of Cboe customer SLIM trades, in millions of dollars, taking account of closing trades using the approach described in Section 3.1. The sample consists of all trades in equity and ETF options that expire by the end of December 2021 that were executed during the period running from January 2020 through June 2021. The final values of the options are the exercise values. Gross profitability is computed assuming that the trade price equals the NBBO midpoint at the time of the trade. Net profitability is computed using the actual trade prices. t-statistics are in parentheses below the estimates.

	Gross performance			Net performance		
	Opening trades, assuming held to expiration	Adjustment for closing trades	Profitability after adj. for closing trades	Opening trades, assuming held to expiration	Adjustment for closing trades	Profitability after adj. for closing trades
All trades			3.59 (2.07)			2.07 (1.19)
Open sells & close buys	-6.09 (-2.77)	5.42 (2.93)	-0.67 (-0.63)	-6.38 (-2.90)	5.35 (2.89)	-1.03 (-0.94)
Open buys & close sells	29.76 (3.57)	-25.50 (-3.38)	4.26 (2.23)	29.23 (3.51)	-26.13 (-3.46)	3.10 (1.58)
Call trades			3.87 (2.21)			2.79 (1.59)
Call open sells & close buys	-9.91 (-5.75)	7.91 (4.93)	-2.00 (-2.26)	-10.07 (-5.83)	7.87 (4.90)	-2.20 (-2.35)
Call open buys & close sells	39.74 (4.84)	-33.87 (-4.82)	5.87 (3.03)	39.33 (4.79)	-34.34 (-4.89)	4.99 (-2.44)
Put trades			-0.29 (-0.41)			-0.72 (-1.02)
Put open sells & close buys	3.82 (2.44)	-2.49 (-2.11)	1.33 (1.38)	3.69 (2.36)	-2.52 (-2.13)	1.17 (1.13)
Put open buys & close sells	-9.98 (-2.01)	8.37 (1.82)	-1.62 (-1.88)	-10.10 (-2.03)	8.21 (1.79)	-1.89 (-2.07)

Table 6**Replication of the performance results in BPS Table VI**

This table shows the results of our replication of the results in BPS Table VI. The sample consists of all SLIM trades of stock and ETF options that expire on or before December 31, 2021 executed on any options exchange during the sample period running from November 4, 2019 through June 2021. The table displays the average daily gross and net profits, where gross profits are based on the midpoint of the NBBO options prices attached to the trade records and net profits are based on the trade price. In both cases, the final value of the option is "the last available price when the data for a certain horizon are not available" (BPS fn. 35)

Gross Performance, \$ mln.							Net Performance, \$ mln.					
Horizon:	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry
Panel A: All trades												
	6.90	8.19	7.19	6.70	6.47	9.63	-4.52	-3.23	-4.23	-4.72	-4.96	-1.75
	(14.43)	(10.42)	(6.52)	(3.76)	(3.70)	(2.72)	(-11.57)	(-4.55)	(-3.74)	(-2.57)	(-2.68)	(-0.47)
Panel B. By trade direction												
Sell	8.18	13.94	18.22	17.13	14.27	-63.13	1.97	7.72	12.01	10.92	8.06	-69.32
	4.65	2.15	1.75	0.93	0.63	-2.13	1.13	1.19	1.16	0.60	0.36	-2.35
Buy	-1.27	-5.74	-11.03	-10.43	-7.80	72.76	-6.49	-10.96	-16.24	-15.64	-13.01	67.57
	-0.70	-0.89	-1.08	-0.58	-0.35	2.44	-3.58	-1.70	-1.59	-0.87	-0.58	2.25
Panel C. By contract type												
Call	5.00	5.79	4.66	3.93	3.37	6.63	-3.14	-2.35	-3.48	-4.21	-4.77	-1.48
	12.78	8.17	4.28	2.16	1.88	2.05	-10.38	-3.46	-3.03	-2.22	-2.50	-0.43
Put	1.90	2.40	2.53	2.78	3.10	3.00	-1.38	-0.89	-0.76	-0.51	-0.19	-0.27
	12.74	8.22	6.93	5.28	4.58	2.61	-8.48	-3.50	-2.21	-0.99	-0.28	-0.22
Panel D. By contract type and trade direction												
Call buy	1.52	6.95	7.14	16.42	21.91	118.96	-2.27	3.16	3.35	12.63	18.12	115.18
	0.72	0.94	0.60	0.82	0.93	4.29	-1.09	0.43	0.28	0.63	0.77	4.14
Call sell	3.48	-1.16	-2.47	-12.49	-18.54	-112.32	-0.87	-5.51	-6.82	-16.84	-22.89	-116.66
	1.75	-0.16	-0.21	-0.61	-0.78	-4.16	-0.44	-0.75	-0.57	-0.83	-0.96	-4.33
Put buy	-2.79	-12.70	-18.16	-26.85	-29.71	-46.19	-4.22	-14.12	-19.59	-28.27	-31.14	-47.61
	-2.24	-3.03	-2.76	-2.49	-1.87	-2.66	-3.43	-3.40	-2.99	-2.62	-1.96	-2.74
Put sell	4.70	15.10	20.69	29.63	32.81	49.19	2.83	13.23	18.83	27.76	30.95	47.34
	3.81	3.58	3.11	2.69	2.04	2.71	2.28	3.12	2.82	2.52	1.93	2.61

Table 7**Performance of all SLIM trades with adjustments for expiring options (Nov. 2019 - June 2021)**

This table repeats the Table 6 analysis, making two changes: (i) It excludes options that have previously expired from the results for the 1-, 2-, 5-, and 10-day horizons; and (ii) for expiring options, it uses the per-share expiration values of $\max(S - K, 0)$ and $\max(K - S, 0)$ for calls and puts, respectively. The sample consists of SLIM trades of stock and ETF options that expire before orduring December 2021 executed on any options exchanges during the sample period running from November 4, 2019 through June 2021. The table displays the average daily gross and net profits, where gross profits are based on the midpoint of the NBBO options prices attached to the trade records and net profits are based on the trade price.

Gross Performance, \$ mln.							Net Performance, \$ mln.					
Horizon:	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry
Panel A: All trades												
	6.93	7.70	6.58	5.42	4.95	11.71	-4.43	-2.72	-2.94	-1.75	-0.55	0.36
	14.54	10.15	6.60	4.90	6.86	3.46	-11.60	-3.86	-2.86	-1.59	-0.78	0.10
Panel B. By trade direction												
Sell	8.92	10.39	6.93	-4.60	-10.12	-71.87	2.75	4.73	1.75	-8.53	-13.15	-78.04
	5.04	1.64	0.76	-0.46	-0.98	-2.44	1.58	0.75	0.19	-0.85	-1.28	-2.66
Buy	-1.99	-2.69	-0.35	10.02	15.06	83.58	-7.18	-7.45	-4.69	6.78	12.59	78.40
	-1.10	-0.43	-0.04	0.99	1.42	2.82	-3.95	-1.18	-0.52	0.67	1.18	2.63
Panel C. By contract type												
Call	5.01	5.45	4.38	3.64	3.06	8.32	-3.08	-2.05	-2.55	-1.66	-1.05	0.24
	12.86	8.07	4.54	3.41	5.52	2.68	-10.37	-3.12	-2.51	-1.52	-1.79	0.07
Put	1.92	2.24	2.20	1.77	1.89	3.40	-1.35	-0.66	-0.38	-0.09	0.50	0.12
	12.80	8.04	6.80	5.23	4.13	2.97	-8.42	-2.61	-1.25	-0.27	1.19	0.11
Panel D. By contract type and trade direction												
Call buy	1.18	7.89	11.82	21.42	20.89	131.72	-2.59	4.39	8.59	18.97	19.00	127.95
	0.56	1.07	1.12	1.95	2.18	4.68	-1.22	0.59	0.81	1.73	1.98	4.53
Call sell	3.83	-2.44	-7.44	-17.78	-17.83	-123.40	-0.49	-6.44	-11.14	-20.63	-20.05	-127.72
	1.90	-0.33	-0.70	-1.63	-1.87	-4.47	-0.25	-0.88	-1.05	-1.89	-2.11	-4.64
Put buy	-3.17	-10.59	-12.17	-11.40	-5.83	-48.14	-4.59	-11.84	-13.27	-12.18	-6.41	-49.56
	-2.49	-2.53	-2.04	-1.57	-0.58	-2.80	-3.64	-2.85	-2.23	-1.69	-0.64	-2.88
Put sell	5.09	12.83	14.37	13.17	7.71	51.53	3.24	11.18	12.89	12.10	6.90	49.68
	4.04	3.04	2.37	1.79	0.78	2.87	2.55	2.63	2.12	1.64	0.70	2.77

Table 8**Performance of all SLIM trades with adjustments for expiring options (Jan. 2020 - June 2021)**

This table displays the performance of all SLIM trades using the BPS approach, with two changes: (i) It excludes options that have previously expired from the results for the 1-, 2-, 5-, and 10-day horizons; and (ii) for expiring options, it uses the per-share expiration values of $\max(S - K, 0)$ and $\max(K - S, 0)$ for calls and puts, respectively. The sample consists of SLIM trades of stock and ETF options that expire before or during December 2021 executed on any options exchange during the sample period running from January 2020 through June 2021. Thus, the analysis is the same as that reported in Table 7, but for a sample period that begins in January 2020 rather than on November 4, 2019. The table displays the average daily gross and net profits, where gross profits are based on the midpoint of the NBBO options prices attached to the trade records and net profits are based on the trade price.

Gross Performance, \$ mln.							Net Performance, \$ mln.					
Horizon:	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry
Panel A: All trades												
	7.42	8.23	7.02	5.78	5.26	10.68	-4.70	-2.89	-3.13	-1.85	-0.58	-1.44
	15.86	10.34	6.50	4.79	6.77	2.92	-11.79	-3.73	-2.77	-1.53	-0.74	-0.38
Panel B: By trade direction												
Sell	9.77	11.58	7.96	-4.19	-9.46	-62.46	3.18	5.54	2.43	-8.37	-12.69	-69.04
	5.13	1.66	0.79	-0.38	-0.83	-1.95	1.67	0.79	0.24	-0.76	-1.12	-2.16
Buy	-2.35	-3.34	-0.94	9.96	14.72	73.14	-7.88	-8.42	-5.56	6.52	12.10	67.60
	-1.18	-0.48	-0.09	0.90	1.26	2.27	-3.99	-1.21	-0.56	0.59	1.03	2.10
Panel C: By contract type												
Call	5.37	5.84	4.67	3.90	3.27	7.28	-3.26	-2.18	-2.73	-1.76	-1.11	-1.36
	13.71	8.10	4.43	3.32	5.44	2.18	-10.43	-3.01	-2.44	-1.46	-1.72	-0.39
Put	2.05	2.39	2.35	1.88	1.99	3.41	-1.44	-0.71	-0.40	-0.09	0.53	-0.08
	13.44	7.96	6.71	5.08	3.98	2.70	-8.32	-2.53	-1.17	-0.26	1.13	-0.06
Panel D: By contract type and trade direction												
Call buy	0.98	7.72	11.63	21.62	20.16	125.08	-3.05	3.98	8.18	19.00	18.15	121.06
	0.42	0.95	1.00	1.79	1.92	4.07	-1.31	0.49	0.70	1.57	1.72	3.93
Call sell	4.39	-1.88	-6.96	-17.72	-16.89	-117.80	-0.22	-6.16	-10.91	-20.76	-19.26	-122.42
	2.00	-0.23	-0.59	-1.47	-1.62	-3.90	-0.10	-0.76	-0.93	-1.73	-1.85	-4.06
Put buy	-3.33	-11.07	-12.56	-11.65	-5.44	-51.94	-4.84	-12.40	-13.74	-12.48	-6.05	-53.45
	-2.37	-2.40	-1.90	-1.46	-0.49	-2.75	-3.49	-2.71	-2.09	-1.57	-0.55	-2.83
Put sell	5.38	13.46	14.91	13.53	7.43	55.35	3.40	11.70	13.34	12.39	6.57	53.37
	3.88	2.90	2.23	1.67	0.68	2.81	2.43	2.50	1.99	1.52	0.60	2.71

Table 9**Performance of Cboe SLIM trades with adjustments for expiring options (Jan. 2020-June 2021)**

This table displays the performance of Cboe SLIM trades using the BPS approach, with two changes: (i) It excludes options that have previously expired from the results for the 1-, 2-, 5-, and 10-day horizons; and (ii) for expiring options, it uses the per-share expiration values of $\max(S - K, 0)$ and $\max(K - S, 0)$ for calls and puts, respectively. The sample consists of Cboe SLIM trades of stock and ETF options that expire before or during December 2021 executed on one of the Cboe exchanges during the sample period running from January 2020 through June 2021. Thus, the analysis is the same as that reported in Table 8, but only for Cboe SLIM trades. The table displays the average daily gross and net profits, where gross profits are based on the midpoint of the NBBO options prices attached to the trade records and net profits are based on the trade price.

Gross Performance, \$ mln.							Net Performance, \$ mln.					
Horizon:	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry
Panel A: All trades												
	2.00	2.32	2.20	1.91	1.96	2.71	-1.00	-0.45	-0.35	-0.06	0.42	-0.29
	14.36	9.95	6.79	6.19	5.72	2.06	-6.80	-1.90	-1.13	-0.20	1.34	-0.21
Panel B: By trade direction												
Sell	2.02	1.44	0.15	-3.17	-4.85	-31.78	0.36	-0.09	-1.27	-4.27	-5.71	-33.43
	4.72	0.86	0.06	-1.08	-1.45	-3.34	0.80	-0.05	-0.53	-1.45	-1.71	-3.50
Buy	-0.02	0.88	2.06	5.08	6.81	34.49	-1.36	-0.36	0.92	4.21	6.13	33.15
	-0.04	0.51	0.84	1.68	1.91	3.57	-2.95	-0.21	0.38	1.40	1.73	3.44
Panel C: By contract type												
Call	1.40	1.76	1.58	1.38	1.16	1.65	-0.71	-0.21	-0.26	-0.06	0.03	-0.46
	12.36	8.75	5.22	5.25	5.01	1.33	-6.41	-1.05	-0.87	-0.22	0.12	-0.37
Put	0.60	0.56	0.63	0.53	0.80	1.06	-0.29	-0.24	-0.09	0.00	0.39	0.17
	10.88	5.89	5.18	4.29	3.89	3.07	-4.74	-2.32	-0.83	0.00	2.17	0.48
Panel D: By contract type and trade direction												
Call buy	0.74	3.37	4.87	7.34	7.15	46.09	-0.23	2.47	4.03	6.69	6.64	45.12
	1.30	1.71	1.71	2.39	2.51	5.07	-0.41	1.26	1.42	2.17	2.33	4.97
Call sell	0.67	-1.61	-3.29	-5.96	-5.99	-44.44	-0.48	-2.68	-4.29	-6.75	-6.61	-45.58
	1.28	-0.85	-1.18	-1.99	-2.13	-5.00	-0.91	-1.42	-1.54	-2.25	-2.35	-5.12
Put buy	-0.76	-2.49	-2.81	-2.26	-0.34	-11.60	-1.14	-2.83	-3.11	-2.48	-0.51	-11.97
	-2.25	-1.98	-1.46	-0.82	-0.09	-2.00	-3.42	-2.26	-1.62	-0.90	-0.13	-2.07
Put sell	1.35	3.05	3.44	2.79	1.14	12.66	0.84	2.59	3.02	2.48	0.90	12.15
	4.11	2.38	1.77	1.00	0.31	2.12	2.52	2.00	1.54	0.88	0.24	2.04

Performance of Cboe customer SLIM trades, using BPS estimates of trade direction

This table displays the performance of Cboe customer SLIM trades using the BPS approach, with two changes: (i) It excludes options that have previously expired from the results for the 1-, 2-, 5-, and 10-day horizons; and (ii) for expiring options, it uses the per-share expiration values of $\max(S - K, 0)$ and $\max(K - S, 0)$ for calls and puts, respectively. The sample consists of Cboe customer SLIM trades of stock and ETF options that expire before or during December 2021 executed on one of the Cboe exchanges during the sample period running from January 2020 through June 2021. Thus, the analysis is the same as that reported in Table 8, but only for Cboe SLIM trades. The table displays the average daily gross and net profits, where gross profits are based on the midpoint of the NBBO options prices attached to the trade records and net profits are based on the trade price.

Gross Performance, \$ mln.							Net Performance, \$ mln.					
Horizon:	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry
Panel A: All trades												
	1.97	2.30	2.17	1.90	1.94	2.69	-1.00	-0.44	-0.35	-0.05	0.42	-0.28
	14.11	9.87	6.67	6.13	5.64	2.03	-6.70	-1.87	-1.14	-0.17	1.35	-0.21
Panel B. By trade direction												
Sell	1.99	1.45	0.15	-3.14	-4.83	-31.51	0.35	-0.06	-1.24	-4.23	-5.68	-33.15
	4.67	0.88	0.06	-1.07	-1.44	-3.33	0.78	-0.04	-0.52	-1.44	-1.70	-3.49
Buy	-0.02	0.85	2.02	5.04	6.77	34.20	-1.35	-0.37	0.89	4.18	6.10	32.87
	-0.05	0.49	0.83	1.67	1.90	3.56	-2.94	-0.22	0.37	1.39	1.72	3.43
Panel C. By contract type												
Call	1.38	1.75	1.56	1.37	1.15	1.63	-0.71	-0.20	-0.26	-0.06	0.02	-0.46
	12.09	8.68	5.17	5.19	4.96	1.30	-6.38	-1.02	-0.86	-0.22	0.10	-0.36
Put	0.59	0.55	0.61	0.53	0.80	1.06	-0.29	-0.23	-0.10	0.01	0.40	0.18
	10.89	5.70	4.90	4.10	3.81	2.96	-4.63	-2.32	-0.86	0.05	2.19	0.49
Panel D: By contract type and trade direction												
Call buy	0.73	3.33	4.82	7.28	7.11	45.83	-0.23	2.44	3.99	6.64	6.61	44.88
	1.30	1.70	1.70	2.37	2.51	5.06	-0.41	1.25	1.41	2.16	2.33	4.96
Call sell	0.65	-1.59	-3.26	-5.92	-5.97	-44.20	-0.48	-2.64	-4.25	-6.70	-6.58	-45.34
	1.26	-0.84	-1.17	-1.98	-2.13	-5.00	-0.91	-1.40	-1.53	-2.24	-2.35	-5.11
Put buy	-0.75	-2.48	-2.81	-2.25	-0.34	-11.63	-1.13	-2.81	-3.10	-2.46	-0.51	-12.00
	-2.25	-1.98	-1.46	-0.81	-0.09	-2.03	-3.41	-2.27	-1.63	-0.89	-0.13	-2.09
Put sell	1.34	3.03	3.42	2.78	1.14	12.69	0.83	2.58	3.01	2.47	0.90	12.18
	4.10	2.38	1.76	0.99	0.31	2.14	2.52	2.01	1.54	0.88	0.24	2.05

Table 11**Performance of Cboe customer SLIM trades, using the correct trade direction**

This table displays the performance of Cboe customer SLIM trades using the correct trade direction. It also uses the two changes to the BPS approach that are also used in Tables 7-10: (i) It excludes options that have previously expired from the results for the 1-, 2-, 5-, and 10-day horizons; and (ii) for expiring options, it uses the per-share expiration values of $\max(S - K, 0)$ and $\max(K - S, 0)$ for calls and puts, respectively. The sample consists of Cboe customer SLIM trades of stock and ETF options that expire before or during December 2021 executed on one of the Cboe exchanges during the sample period running from January 2020 through June 2021. Thus, the analysis is the same as that reported in Table 8, but only for Cboe SLIM trades. The table displays the average daily gross and net profits, where gross profits are based on the midpoint of the NBBO options prices attached to the trade records and net profits are based on the trade price.

Gross Performance, \$ mln.							Net Performance, \$ mln.					
Horizon:	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry	Intraday	1 Day	2 Days	5 Days	10 Days	Expiry
Panel A: All trades												
	0.82	1.51	0.98	1.14	0.82	3.59	-0.70	0.10	-0.32	0.13	0.03	2.07
	4.77	4.06	2.37	2.39	1.58	2.07	-3.95	0.28	-0.79	0.27	0.05	1.19
Panel B: By trade direction												
Sell	1.43	1.07	-0.44	-3.57	-5.52	-31.59	0.52	0.22	-1.23	-4.19	-6.01	-32.64
	3.09	0.63	-0.18	-1.21	-1.61	-3.32	1.10	0.13	-0.50	-1.42	-1.75	-3.43
Buy	-0.61	0.44	1.42	4.72	6.34	35.18	-1.22	-0.12	0.91	4.32	6.03	34.71
	-1.33	0.25	0.57	1.53	1.76	3.55	-2.66	-0.07	0.37	1.40	1.68	3.50
Panel C: By call or put												
Call	0.67	1.17	0.68	0.72	0.41	3.87	-0.42	0.16	-0.27	-0.03	-0.19	2.80
	5.30	4.18	1.94	1.88	1.25	2.21	-3.32	0.54	-0.80	-0.09	-0.57	1.59
Put	0.15	0.33	0.30	0.42	0.41	-0.29	-0.28	-0.05	-0.05	0.16	0.21	-0.73
	1.81	1.65	1.27	1.52	0.98	-0.41	-3.03	-0.29	-0.20	0.60	0.51	-1.02
Panel D: By call or put and trade direction												
Call buy	0.37	3.09	4.45	7.08	6.90	47.65	-0.08	2.66	4.06	6.77	6.65	47.20
	0.66	1.57	1.55	2.25	2.38	5.00	-0.15	1.35	1.42	2.16	2.30	4.95
Call sell	0.29	-1.92	-3.78	-6.36	-6.49	-43.78	-0.34	-2.51	-4.33	-6.81	-6.84	-44.41
	0.54	-0.99	-1.34	-2.11	-2.27	-5.07	-0.62	-1.30	-1.53	-2.25	-2.40	-5.15
Put buy	-0.99	-2.65	-3.03	-2.37	-0.56	-12.47	-1.14	-2.78	-3.15	-2.45	-0.62	-12.62
	-2.86	-2.00	-1.49	-0.81	-0.14	-2.09	-3.30	-2.11	-1.55	-0.84	-0.16	-2.12
Put sell	1.14	2.98	3.34	2.79	0.97	12.18	0.86	2.73	3.10	2.61	0.83	11.90
	3.40	2.36	1.73	1.00	0.26	2.01	2.55	2.15	1.61	0.94	0.22	1.96